Chapter 3
Small-Group vs. Competitive Learning in Computer Science Classrooms: A Meta-Analytic Review

Sema A. Kalaian
Eastern Michigan University, USA

Rafa M. Kasim
Indiana Tech University, USA

ABSTRACT

The focus of this meta-analytic chapter was to quantitatively integrate and synthesize the accumulated pedagogical research that examined the effectiveness of one of the various small-group learning methods in maximizing students' academic achievement in undergraduate computer science classrooms. The results of the meta-analysis show that cooperative, collaborative, problem-based, and pair learning pedagogies were used in college-level computer science classrooms with an overall average effect-size of 0.41. The results of the multilevel analysis reveal that the effect sizes were heterogeneous and the effects were explored further by including the coded predictors in the conditional multilevel model in efforts to explain the variability. The results of the conditional multilevel model reveal that the effect sizes were influenced significantly by both instructional duration and assessment type of the studies. The findings imply that the present evidence-based research supports the effectiveness of active small-group learning methods in promoting students' achievement in computer science classrooms.

INTRODUCTION

For the last three decades, there have been numerous and consistent calls for instructional reforms and innovations in science, technology, engineering, and mathematics (STEM) education by the national and federal agencies as well as professional organizations such as the American Association for the Advancement of Science (2005), National Science Foundation (1996), National Research Council (2001), and the Accreditation Board of Engineering and Technology (2008).

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In their publications and recommendations, they emphasized the need to examine the existing teaching methods and student-learning processes. They also emphasized the need to develop and explore innovative teaching practices that require the implementation of one of the various forms of active methods of small-group learning pedagogies in STEM college classrooms including computer science classrooms. Cooperative learning, collaborative learning, pair programming, problem-based learning, and team-based learning are examples of such innovative active small-group pedagogies. In addition, these calls emphasized the requirement that the graduates from these various STEM disciplines including computer science fields of study to have the ability to communicate effectively, think reflectively and critically, and function effectively in cooperative and collaborative multidisciplinary team-based educational settings, which mirror the real STEM including computer science related workplace environments. Thus, teamwork has long been an important component of computer science education since it models the way computer programing and software development in industrial settings nationwide and throughout the world. The global software development (GSD) industry is an example of such contextual setting.

In response to these numerous calls and recommendations for educational reform, many STEM educators, including computer science instructors and educators have been developing, experimenting, adopting, and/or implementing different forms of the various innovative active small-group learning methods in their classrooms. As a result of developing and using these active learning methods, many empirical primary studies have been conducted to examine and evaluate the effectiveness of these active small-group learning pedagogies compared to the traditional competitive instructional methods such as lecture-based instruction and individualized instruction in increasing the students' achievement across all levels of schooling (K-12 and college).

BACKGROUND

Small-group learning is defined as an instructional method in which small groups of students work together to accomplish a shared common learning goal. These small-group learning methods stem from both of the cognitive and social constructivist philosophies of learning. These philosophies view that each individual in a learning group actively and collaboratively constructs knowledge based on previously learned conceptual knowledge and through his or her experiences and social interactions with the other learners in their teams. Cooperative learning, collaborative learning, pair learning/programming, problem-based learning, inquiry-based learning, and team-based learning are such systematic forms of active small-group learning methods. In collaborative learning environments, students perceive that they can reach their common learning goals if they work collaboratively with the other group members. In competitive environments, students perceive that they can reach their goals if and only if the other students in the classroom cannot achieve their learning goals (Johnson & Johnson 1989; Johnson, Johnson, & Stanne, 2000; Johnson & Johnson, 2009; Qin, Johnson, & Johnson, 1995).

Inspired by many studies focusing on the effectiveness of various forms of small-group methods, computer science instructors have begun to shift from the use of traditional competitive lecture-based pedagogies and individualized learning to innovative methods of learning/teaching, which encourage collaboration, cooperation, self-motivation, and self-direction. For example, McDowell, Werner, Bullock, & Fernald (2002) stated that collaboration is an effective pedagogy for teaching introductory programming because pair programming (a) produces more efficient and bug free codes, (b) leads to better team communication and comprehension of the programming problems, and (c) enhances programmers' satisfaction, enjoyment, and confidence in their programming solutions. The increased popularity